

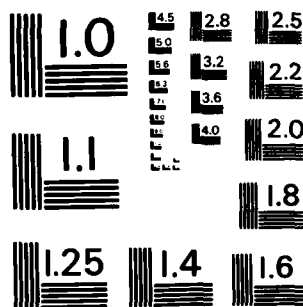
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ABSTRACT

Thirty curved, mesial roots of extracted human mandibular first molars were selected to histologically evaluate the planing ability of two new endodontic files. Mesiolingual canals were serially prepared with one of three types of endodontic files. Conventional K-type files were used as control instruments; and recently marketed K-Flex® and Dynatrak® files were used as experimental instruments. The difference in canal wall planing ability among the three file types was measured by the percentage of predentin and/or dentin removed from the walls of the mesiolingual canals as compared to the walls of the uninstrumented mesiofacial canals. Statistical comparison of the mean percentage scores of canal wall planed at $P < \alpha = .05$ showed no statistically significant difference among the three file types. Statistical comparison of the mean operating times at $P < \alpha = .05$ showed that the Dynatrak® file gave instrumentation times that were significantly less than either the K-Flex or the K-type files.

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STATEMENT(s):

A HISTOLOGIC COMPARISON OF THE CANAL
WALL PLANING ABILITY OF TWO NEW
ENDODONTIC FILES

By

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ABSTRACT

Thirty curved, mesial roots of extracted human mandibular first molars were selected to histologically evaluate the planing ability of two new endodontic files. Mesiolingual canals were serially prepared with one of three types of endodontic files. Conventional K-type files were used as control instruments; and recently marketed K-Flex® and Dynatrak® files were used as experimental instruments. The difference in canal wall planing ability among the three file types was measured by the percentage of predentin and/or dentin removed from the walls of the mesiolingual canals as compared to the walls of the uninstrumented mesiofacial canals. Statistical comparison of the mean percentage scores of canal wall planed at $P \leq .05$ showed no statistically significant difference among the three file types. Statistical comparison of the mean operating times at $P \leq .05$ showed that the Dynatrak® file gave instrumentation times that were significantly less than either the K-Flex or the K-type files.

REVIEW OF THE LITERATURE

Endodontic therapy for pulpal and associated periradicular disease has traditionally been directed towards microbial control, complete tissue removal, and obturation of the canal.¹⁻⁴ Currently, some endodontists^{5,6} believe that a minimum amount of canal debridement and enlargement is required for microbial control and to facilitate obturation. A recent investigation⁷ supports the fact that canal enlargement and irrigation reduces the bacterial count of infected root canals. Anaerobic sampling techniques showed that canals with necrotic debris could be rendered sterile over fifty percent of the time using only conventional instrumentation in conjunction with irrigation with physiologic saline.

Despite the importance of canal debridement in endodontic therapy, our techniques frequently are unable to totally rid the radicular pulp canal space of dentinal sludge, cellular debris, and tissue.⁸⁻¹⁴ Inadequacies of instrumentation in all canals, but especially in mesial canals of mandibular first molars and mesiofacial canals of maxillary first molars have been described by Haga.¹⁵ One could speculate that the curved mesial canals of mandibular first molars have traditionally proven difficult to clean because of the anatomical constraint of bicurved canals linked by intercanal "fins" and "webs" of pulp tissue. Studies on anterior^{13,16} and posterior^{14,16} teeth have shown that root canal "fins" are frequently never instrumented. Therefore, intercanal dentinal "coves" can and often do harbor pulp tissue "fins" in various stages of degeneration which are left behind when canals are obturated. Using an in vitro study model, Weine et. al.¹⁷ described a technique modification for curved canals called step back filing. They claimed it prevented apical "zips" and "elbows". The efficacy of step back filing was reconfirmed

by another in vitro study that showed the step back preparation was significantly more effective than non-serial preparation at all levels.¹⁸ Histologic evaluation of the adequacy of planing of curved and straight canal walls furnished further evidence that the step back technique was significantly superior to reaming or filing alone.¹⁹

Since step back filing has been shown¹⁷⁻¹⁹ to be superior to other techniques, it serves as a meaningful standard for comparing new techniques of canal debridement.

Presently, several new conventional and automated root canal files are being marketed as superior to others in one or more physical properties such as shape, flexibility, cutting ability or ease of use. There has been no independent study published that evaluates the ability of the new files to clean and shape curved root canals. The purpose of this project is to compare, through histologic evaluation of serially prepared root canals, the ability of Dynatrak and K-Flex files to clean and shape the radicular pulp canal space of curved mesial root of mandibular molars.

METHODS AND MATERIALS

Thirty extracted human mandibular first molars were selected for the study. The selection criteria required mature mandibular first molars with mesial curvature greater than ten and less than thirty-five degrees as described by Schneider,²⁰ and radiographically separate root canals.

The thirty teeth were randomly divided into three groups of ten teeth each (Groups A, B, and C). The grouped teeth were placed in separate, labeled containers with 10% formalin and stored at room temperature.

The mesiolingual canals instrumented with K-type[§] files served as positive controls. The uninstrumented mesiofacial canals of all groups served as negative controls. Group A was instrumented with K-Flex[†] files, group B with Dynatrak files⁺ and group C with K-type files.

Group B was instrumented after completing Ransom and Randolph's self study course²¹ for the controlled power assisted preparation of root canals. Since the smallest instrument in the Dynatrak system was a #15 file, #8 and #10 K-files were used to start the instrumentation of the mesiolingual canals.

Prior to mounting the tooth in typodont*, the mesial root was grooved vertically with a #557 high speed carbide bur on the facial and mesiolingual surfaces (Figure 1). The two grooves served to identify the mesiofacial and mesiolingual canals and the mesial and distal root surfaces in the histologic sections. The typodont mounted in a manikin was used to simulate clinical conditions. All instrumentation was performed by one clinician.

Coronal access was accomplished using standard endodontic technique. The experimental canals were gently broached whenever possible and each was prepared using new instruments and distilled water irrigation. The apical portion of the canal was serially enlarged with a filing motion²² to at least a #25 file one millimeter from the radiographic apex; this was called the master apical file (MAF). The remaining length of the canal was stepped back²³ in .5 millimeter increments to a #60 file at the cervical third of the canal. Recapitulation of all canals was done with a file one size smaller than the master apical file after every second file size increase. After final recapitulation

[§]Union Broach, 36-40 37th St., Long Island City, N.Y. 11101

[†]Sybron/Kerr, Box 455, Romulus, MI 48174

⁺Ransom & Randolph, 324 Chestnut St., Toledo, OH 43604

*Columbia Dentoform Corp., 49 East 21st St., New York, N.Y. 10010
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tulation, the experimental canals were thoroughly irrigated and dried with paper cones. Time required to complete instrumentation was noted and recorded. A small cotton pledget was pushed approximately two millimeters below the orifice of the experimental canal. The tooth was then removed from the typodont and the root severed at its cervical end with a #557 high speed bur. The cervical end of the severed root was rinsed with distilled water until adherent dentin from the cut was washed away. Cotton pledgets were removed and the root length measured and recorded. The severed root was then returned to its original container which contained fresh 10% formalin.

Decalcification of instrumented roots was accomplished by immersion in 20% formic acid for seventy-two hours. The roots were then subjected to a standard alcohol drying technique and subsequently mounted in paraffin blocks for sectioning. Sections six to eight microns in thickness were obtained from each root every 300 microns starting from the anatomic apex. The tissue specimens were stained with hemotoxylin and eosin and prepared in the customary manner for evaluation with a light microscope.

Histologic grading of cross sections began at 0.9 to 1.2 millimeter from the anatomic apex of the mesiolingual canal (Figure 2). The specimens were evaluated blindly for the degree of completeness of removal of predentin or dentin by one independent examiner as described by Walton.¹⁹ In each cross section the amount of predentin or dentin removed was calculated as a percentage of the total canal surface¹⁹ (Figures 3 and 4). In addition to determining the percentages of canal wall planed, the diameters of experimental canals were compared to the diameters of uninstrumented canals. When instrument contact with canal walls could not be confirmed, the scorer made a percentage assessment based on whether or not the experimental canal was larger than the uninstrumented control canal. If the experimental canal was

larger than its uninstrumented neighbor at any given level of examination, the scorer assumed the differences in diameter were the result of instrumentation. Debris within the canal was ignored during the scoring process.

The scores for all histologic sections of each root were averaged. This gave a mean percent score for each root. The mean percent score for each root in each group was totalled and the mean percent determined for the group. The mean percent scores for each group were then tested for significant differences between and within groups using the analysis of variance test at $P \leq .05$ (ANOVA).

RESULTS

The mean scores of planing ability for all three types of files studied was 81% or better. K-Flex files scored slightly higher (86.18%) than Dynatrak (81.91%) and K-type files (81.72%). The mean scores of each group and the range of scores falling within one standard deviation (S.D.) of the group mean are shown in Table 1 and Figure 5. An analysis of the difference shown in Figure 5 using a one-way ANOVA (F-test) shows that there was no statistically significant difference between or among the groups at $P \leq .05$ (Table 2).

The mean operating time for each group was: K-Flex = 29.1 min; K-type = 25.0 min; and Dynatrak = 19.6 min (Table 3). An analysis of the mean operating times using a one-way ANOVA shows that the Dynatrak files required the least time to complete instrumentation (Table 4 and Figure 6). The differences in mean operating times between the Dynatrak and either the K-Flex or the K-type files were statistically significant at $P \leq .05$ (Table 4).

DISCUSSION

This investigation was done to determine if the new files were superior to the K-type file in ability to enlarge the canal space. While the data fail to show a significant difference in planing efficiency, it was interesting to note that the K-Flex system registered a slightly higher score than did the Dynatrak system or K-type file. The results in Figure 5 also show that approximately 68% of the K-Flex scores (one S.D.) are tightly clustered about the group mean. The Dynatrak group, and to a lesser extent the K-type file group, have 68% of their scores spread over a wider range. This might suggest that the K-Flex instrument gave more consistent predentin and dentin removal.

Human teeth mounted in a manikin were selected as the model in which to evaluate the new instruments in order to simulate clinical conditions. The mesiolingual canal of mandibular first molars was selected as the experimental canal because this canal has a smaller diameter than the mesiofacial canal.²⁴ If the post instrumentation cross sections showed the mesiolingual canal to be larger than the mesiofacial canal, the evaluator assumed the size difference to be the result of instrumentation. The difference in canal diameters, coupled with the presence or absence of predentin, gave reliable evidence of instrument use (Figures 3 and 4).

During tooth selection, the authors observed that fifty percent of the mesial roots with two canals and two foramina frequently had a characteristic shape. The mesial root often had a faciolingual step. When the root was viewed from the proximal, the mesiofacial canal was the longer of the two canals (Figure 2). This information could prove useful during clinical length determination (Figure 7).

In spite of radiographic evidence of two separate mesial canals, over half the roots had intercanal communications containing pulpal tissue (Figure 8). The intercanal communications frequently alternated with dentin as one scanned the serial sections (Figure 1). This meant that total soft tissue removal was impossible in this area unless the mesiofacial and mesiolingual canals were intentionally connected during instrumentation. In curved roots, intentional connection of the two canals would probably lead to furcal perforation.

The presence or absence of the predentin layer may not be a good monitor of instrument effectiveness as claimed by some researchers.¹⁹ Some of the teeth were obviously from older individuals and had no predentin layer to evaluate. This emphasizes the importance of rigid controls in comparison studies of this type.

Distilled water was chosen instead of NaOCl because of the potential effect NaOCl may have had on the organic component of the predentin.

It was difficult to control all variables intrinsic to this kind of study. Only one operator and one evaluator was used to decrease instrumentation and scoring variability. The variation in root curvature from one tooth to the next, the size of canal, and the amount of predentin were three obvious biologic variables. Additionally, in the Dynatrak group, initial instrumentation was done with K-type files. This was necessary because the Dynatrak files were not available in sizes #08 and #10.

Subjectively, K-type files tended to wander from the canal more frequently and to a larger degree than did K-Flex or Dynatrak. This failure to follow the original canal produced severe mid and cervical root canal ellipticism with resultant near perforations (Figure 9). These findings for a K-file type are in agreement with those of Jungman et al.²⁶ Conversely, the Dynatrak

files seemed to overprepare the canals while not necessarily cleaning it (Figure 10).

SUMMARY AND CONCLUSIONS

Since efficient canal wall planing is important in endodontics, selection of an instrument to accomplish this goal is a relevant consideration. This study was performed to determine if K-Flex files or Dynatrak files were superior to K-type files. The ability of two new endodontic files to enlarge the mesio-lingual canals of curved mesial roots of extracted human mandibular first molars was tested and compared to that of K-type files. There was no statistically significant difference in the ability of the K-Flex, Dynatrak, or K-type files to remove radicular predentin and/or dentin. The Dynatrak files, however, gave instrumentation times that were significantly less than either the K-Flex or the K-type files.

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FIGURE LEGEND

- Figure 1. Histologic cross section of mesial root 6.3 mm from apex showing facial (F) and mesiolingual (ML) identification grooves and intercanal dentin (D). Magnification X25.
- Figure 2. Mesial view of specimen B-3 showing point of origin of histologic interpretation. (Arrow). Facial surface (F). Lingual surface (L).
- Figure 3. Higher magnification of mesiofacial control canal of figure 1 showing: dentin (D); predentin (PD); and pulp tissue (P). Magnification X158.
- Figure 4. Higher magnification of mesiolingual canal of figure 1 instrumented with K-files showing: dentin (D); pulp tissue (P); and a circumferential absence of predentin. Magnification X158.
- Figure 5. Mean percentage score and standard deviation of canal wall planed for each instrument type.
- Figure 6. Mean instrumentation time and standard deviation for each instrument type.
- Figure 7. Periapical radiograph of specimen B-3 (Figure 2) showing the longer mesiofacial root. (Arrow).

- Figure 8. Cross section of mesial root shown in Figure 1 at 4.2 mm from the apex showing intercanal communication containing pulp tissue (P). Magnification X25.
- Figure 9. Cross section of mesial root 6.1 mm from apex showing K-files cutting towards the furca. The distal wall of the prepared canal is .58 mm from the exterior of the root. Magnification X25.
- Figure 10. Cross section of mesiolingual canal instrumented with Dynatrak 8.1 mm from apex showing overprepared canal with pulp tissue (P) and predentin (PD) remaining in the original root canal. Dentin (D) walls of overprepared canal. Magnification X158.

TABLE LEGEND

- Table 1. Mean percentage scores of canal wall planed for Dynatrak, K-Flex, and K-type instruments.
- Table 2. Analysis of variance of mean percentage canal wall planing scores for Dynatrak, K-Flex, and K-type instruments.
*Significance at $P \leq .05$ is reached with F-ratio ≥ 3.4 .
- Table 3. Mean instrumentation times for Dynatrak, K-Flex, and K-type instruments.
- Table 4. Analysis of variance of mean instrumentation times for Dynatrak, K-Flex, and K-type instruments. *Significance at $P \leq .05$ is reached when F-ratio ≥ 3.4 .

Carlos E. del Rio

CREDITS

The authors would like to thank Dr. Steve Senia and Dr. Steve Montgomery for their kind suggestions and continued encouragement and support during this project. Additionally, we would like to thank Dr. Joel Alexander for his review of the manuscript and his constructive editorial comments.

Group	Count	Mean	Standard Deviation
K-Flex	10	86.18	6.10
Dynatrak	10	81.91	16.04
Union Broach	10	81.72	13.30
Total	30	83.27	12.27

Table 1. Mean percentage scores of canal wall planed
for Dynatrak, K-Flex, and K-type instruments.

Source	SS	df	MS	F-ratio	F-probability
Between Groups	127.14	2	63.57	0.404*	0.6713
Within Groups	4243.73	27	157.17		
Total	4370.87	29			

* $p \leq .05$

Table 2. Analysis of variance of mean percentage canal wall planing scores for Dynatrak, K-Flex, and K-type instruments.

*Significance at $P_{\leq .05}$ is reached with F-ratio ≥ 3.4 .

Group	Count	Mean	Standard Deviation
K-Flex	10	29.10	5.50
Dynatrak	9	19.66	3.84
Union Broach	10	25.00	6.16
Total	29	24.75	6.42

Table 3. Mean instrumentation times for Dynatrak, K-Flex, and K-type instruments.

Source	SS	d.f.	MS	F-ratio	F-probability
Between Groups	422.41	2	211.20	7.493*	0.0027
Within Groups	732.90	26	28.18		
Total	1155.31	28			

* $p \leq .05$

Table 4. Analysis of variance of mean instrumentation times for Dynatrak, K-Flex, and K-type instruments.

*Significance at $P_{\leq .05}$ is reached when F-ratio ≥ 3.4 .

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